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and before it we scudded, until it had freshened to a tremendous gale, with a frightful following sea, which sometimes swept the deck fore and aft, and obliged us to carry not only a heavy press of sail, but eventually scud until we could not safely heave to.

In this condition we passed Cape Walsingham and Cumberland Sound, into which I was anxious to look, with the view of wintering in Hogarth Inlet, where I could advantageously carry out several series of useful observations, and from whence I hoped to continue and complete a diligent search of the coast from the River Clyde to the Meta Incognita of the Charts, which thereabouts seem to be all guesswork.

October 13th brought some little improvement in the weather, but now we had been forced past our port, and my ice-masters, both old experienced Arctic voyagers, earnestly begged that I would relinquish the attempt to get in with the western coast at this late period of the season, declaring that the coast could not be safely approached but in fine weather, and that every thing now showed the winter to have fairly set in. After waiting two days longer in hopes of a change, I yielded to the advice of these two ancient mariners, and putting up the helm for England, arrived at Peterhead in four months precisely from the day we sailed; having during that period reached a higher degree of latitude in these seas than any of my predecessors.

Places named in Map.—*Isles*: Manson, Three Sister Bees, Northumberland, Herbert, Milne, Tyrconnel, Prudhoe, Sutherland, Littleton, Louis Napoleon, Mittie, Coburg and Kent, Cone and Smith.—*Capes*: Abernethy, Alexander, Robertson, Albert, Crystal Palace Cliffs, Camperdown, Sabine, Cracroft, Wade, Frederick VII., Douglas, Faraday, Norton Shaw, Macdonald, Waldegrave, Hardy, and Newman Smith.—*Heads*: Victoria, Stafford, Dunsterville.—*Points*: Thelluson, Gale, Paget, Bence, Boger, Sir R. Inglis, Maxwell.—*Mountains*: Prince of Wales, Leeds, Bolton, Glentworth.—*Straits*: Murchison and Glacier.—*Bays*: Princess Marie, Lady Franklin, Hyde Parker.—*Bight*: Thorold.—*Inlets*: Cadogan, Talbot.

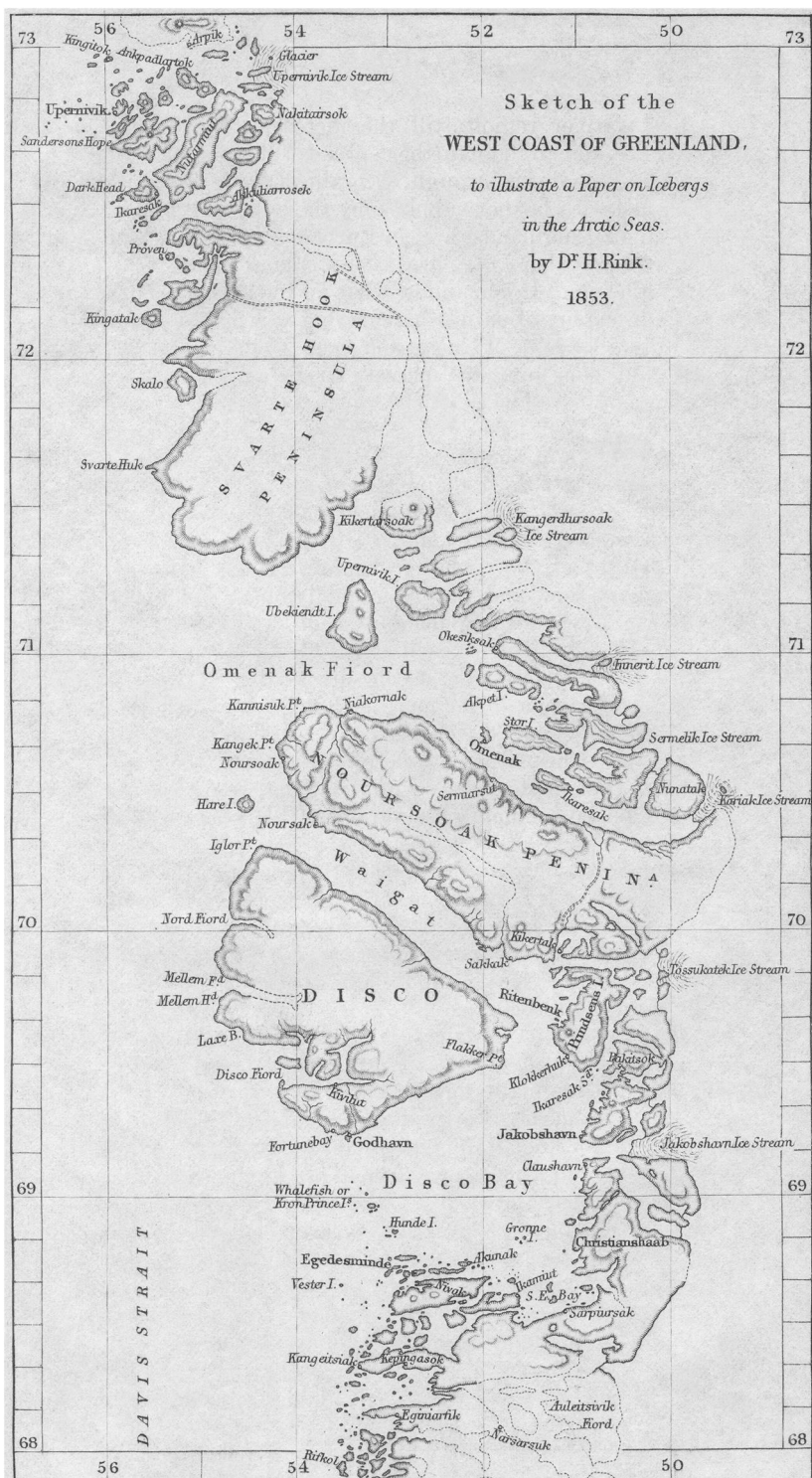
X.—On the large Continental Ice of Greenland, and the Origin of Icebergs in the Arctic Seas. By Dr. H. RINK, of Copenhagen.

Communicated by Dr. SHAW.

Read May 9, 1853.

IT is a well-known fact that all the ice formed from snow upon the surface of land, where the heat of summer is incapable of melting and preventing its gradual increase, has a tendency to extend and move downward, as water would do, according to the same laws, in case rain instead of snow had fallen upon the surface. Those masses of snow accumulated in high regions of mountain chains, even in the hottest parts of the globe, gather in the valleys, which thus form the natural drainage for the highlands, and being congealed into a compact body of ice, move slowly down into lower

and warmer regions, till the increasing heat, by thawing them, sets a limit to their further spread. These masses of compact ice spreading down through the valleys or clefts, and constantly furnished with farther supplies by the snow accumulated in the surrounding highlands, are, in Europe, seen on the largest scale upon the Alps, where they are known under the name of "Gletcher," or glaciers. It is manifest what an important part they perform in the economy of nature by carrying down into warmer regions the annual excess of snow and ice, which, without these means, would continue to increase perpetually on the tops of the mountains. The height at which snow can lie from one winter to another, and form perpetual ice, is very different in different latitudes and climates; but the depth to which the glaciers are able to carry down the annual excess of perpetual ice is, moreover, dependent on the height and extent of the snowy regions from which it receives its supply. In the Alps, the lowest glacier line is 3600 feet above the surface of the sea. In the Polar regions primary snow and ice are found lying at much lower levels than those to which the glaciers descend in the Alpine regions, so that glaciers frequently reach down to the very surface of the sea, or *even below it*. But the ocean surrounding the coasts of those Arctic regions presents a far more striking phenomenon in the masses of floating ice, called icebergs. We shall hereafter have occasion to speak of the nature of these masses, and the conclusions drawn from them as to their origin; but here we will merely briefly rehearse the common observations of travellers who have navigated the seas of Greenland on both sides. The larger icebergs rise above the surface of the sea to the height of from 100 to 150 feet and upwards, and some are 4000 feet in circumference. The part *above* can scarcely be considered more than one-eighth of that *below* the surface of the water, so that the cubic contents of the iceberg may amount to 100,000,000 of cubic ells, or about 66,000,000 cubic yards; a fragment of ice, which, if we suppose it to be fairly landed, would form a mountain about 1000 feet in height. All agree that the icebergs of these Arctic seas are originally formed on *terra firma* from the snow and rains which, from the severity of the climate, are never able to reach the ocean in a fluid state, but which, in the course of years, are transformed into a mass of ice, and are then, through some physical agency, thrust forward into the sea. But now the question arises, in what country have such crusts of ice been met with? and how have they been seen to detach such huge fragments so far into the ocean as to enable them to float? To those who have described these icebergs, on seeing the high coasts of Greenland and Spitzbergen, with their mountain tops perpetually covered with ice and snow, and in many places the ice from the highlands extending itself into the valleys and filling them to the very sea-



shore, where the steep icy walls are chafed by the waves, and small fragments are broken loose and thus set adrift on the surface of the water, it very naturally occurred that the icebergs might derive their origin from such gletcher (glacier) valleys. This opinion has been entertained by all who have observed glacier (gletcher) valleys, as well as floating icebergs ; but at the same time it would seem strange that the most experienced navigators of the Polar seas have never mentioned seeing an iceberg protruding from the shore, or the glaciers in the act of detaching fragments from their mass, which in any degree could in bulk be compared to an iceberg, although the number of these, which unquestionably are produced in the Polar regions every year, is so surprisingly large. It is also with good reason that Scoresby wonders that icebergs are so rarely met with in the neighbourhood of Spitzbergen, although that Polar land is said to be particularly distinguished by its numerous glaciers reaching down to the sea ; while, on the contrary, icebergs are far more frequent in Baffin Bay. He explains this difference by the different nature of the coasts in both places ; but it will be our business, in the subsequent pages, to show that a much more essential cause produces this difference—a cause to be looked for in the nature of those tracts of land in which so great an excess of ice is produced annually. The author of these pages, during a residence of several years in Greenland, enjoyed an opportunity of becoming acquainted with the seven northernmost Danish settlements, *i. e.*, that part of the E. coast of Baffin Bay which lies between 68° and 74° N. lat., and from which, in all probability, a great number of the largest icebergs, which pass down Davis Strait, issue. He has thereby been led to adopt a view respecting them, with reference to which he preliminarily begs leave to propound the following main points, before he proceeds to establish it by detailed proofs deduced from the local circumstances of the coast above alluded to.

1. Where large icebergs proceed from the coast, they regularly issue every year in large numbers from places *in extent about 4 miles*, so that the annual production of ice amounts to thousands of cubic yards, but occasionally leaving interstices from which few or no icebergs are sent forth for some time. Considering that in other neighbouring tracts the snow and rain reach the ocean in a *fluid* state, with few exceptions, this quantity is far too great to be reproduced only by the yearly increase of ice in the hilly region immediately surrounding a solitary valley or ravine. As the glaciers in such valleys or ravines correspond to, or take the place of mountain streams, the places, from which the icebergs proceed, represent, as it were, the mouths of rivers, carrying off water from a large tract of upland. The ice thrust forth into the sea, in the form of massy mountains, is originally formed over an enormous extent of country, from whence it, by an agency similar

to that by which the progress of glaciers is effected, is thrust forward to and brought to a point at the place from which the icebergs proceed. For the formation of icebergs accordingly a tract of land of a certain extent is necessary, in which the sea forms so few and small creeks or inlets that rivers or watercourses of some magnitude must necessarily be present.

2. Where the above-mentioned condition exists, in conjunction with the necessary temperature of the climate, the formation of ice does not proceed from certain mountain heights, but *the whole country is covered with ice to a certain elevation; mountains and valleys are levelled to a uniform plane; the river-beds are concealed, as well as every vestige of the original form of the country.* A movement, commencing *far inland*, thrusts the outer edge of this mass of ice forward towards the sea; and when it reaches the frith, it may be seen to sink, and to diverge and even extend out several miles. There the agency of the *obliterated rivers* may be observed in the greater or lesser rapidity with which the matter in a solid state is carried forward to the ocean. The massy crust, *still preserving its continuity*, proceeds from the shore, borne by the sea, until some circumstance or other destroys the equilibrium, and breaks some fragments off the outer edge, which is again thrust forward, and again detaches new fragments, thus continually renewing the supplies from the interior.

3. A tract or *body of land of the requisite size* is, in the northern hemisphere, *only to be found in Greenland*, and more especially in that part which lies to the N. of the Arctic Circle, where in the interior, beyond the inlets of the sea, the country increases in breadth from E. to W., and affords space for the original *birth-place* of these large icebergs. Neither Spitzbergen, nor the narrower parts of Greenland, nor the peninsula nor the islands which surround it, are adequate in size to produce the yearly excess of indissoluble ice which, *from that large and unknown continent, is very slowly protruded*; and, as it seems, in a lesser degree toward the eastern shores of Greenland, along which the icebergs are driven past Cape Farewell, the greatest quantity going to the W., into Baffin Bay. The friths or fiords, which, piercing far into the country, receive and transmit the icebergs, are called *ice friths*.

The aforementioned tract of coast along Baffin Bay, to which we will confine our present remarks, and which is exhibited in the subjoined map, is particularly characterised by the deep inlets and branches of the sea—by that mixture of land and water—that labyrinth of peninsulas and islands—by that peculiar configuration, which provides the means of subsistence to the inhabitants, and thus altogether supplies their nourishment from the ocean.

From the outermost isles, these arms of the sea commonly reach from 50 to 100 miles inland, *where every one of them terminates*, and where the body of continental land commences, a vast region

completely destitute of animal life, and buried under a continuous tract of ice, which only terminates about 800 miles more to the E., in the high unknown latitudes of eastern Greenland. Let us suppose now a line drawn from S. to N., touching the inner extremities of all the deep inlets, and let us call the group of peninsulas and islands, which lie to the westward of it, the *outskirts* of the land, and the compact continent to the E. the *inland*.

The area of the outskirts of N. Greenland may be estimated at about 30,000 square miles. But the above-mentioned divisions, with their numerous ramifications of inlets and bays, cause it to spread over a far greater surface. If we at the same time consider its thin population and severe climate, it is no matter of surprise that this part of Greenland has been hitherto so very little known, and that there exist large tracts of country unvisited but by a few natives, and difficult to classify, either as islands or as attached to the continent. Most Europeans leave Greenland without even having seen the extensive and uniform *table-land of ice* which spreads its waste tract over all the eastern regions, and without having ever visited the termination of the fiords into which this ice annually throws off its enormous excess in the shape of colossal fragments, amounting to many millions of cubic feet. The places where such mighty and extraordinary natural phenomena take place are, generally speaking, far removed to the eastward from the inhabited coast-land, and all access to them over the inlets and friths, on account of the extraordinary accumulation of drift-ice in summer, and the breaking up of the solid salt-water ice by the motion of the glaciers in winter, is rendered difficult and dangerous in the extreme for the explorer. But at the *mouths* of the icy friths we have an opportunity of observing the masses which annually pass off into the ocean, and we are then perfectly astonished and wonder-struck when we reflect in what parts of the country such stupendous quantities of ice can have been produced and flitted down to one single inlet. In considering the *outskirts*, nothing meets our eye that would indicate any cogent reason for such an accumulation of ice even in that severe climate. We observe on these 2000 square miles of islands and peninsulas the snow and ice of a whole winter lying below the level of 2000 feet, annually thaw away before the heat of the sun in the month of June—a summer heat sufficient to produce the vegetation of several hundred species, which blossom and produce ripe seed before the frost of the subsequent early winter causes them to fade at the latter end of August. This heat would probably be sufficient to thaw double or triple the mass of snow produced by the preceding winter, before the commencement of the fresh accumulations of its successor.

Although the *mean* temperature of the year on this coast is some degrees below the freezing point, we here find the ordinary

law of nature maintained; according to which, even in warmer climes, the formation of perpetual snow and ice is dependent upon a certain elevation over the surface of the water: but here *this elevation* is of course less. All observations made on this subject lead to the result, that somewhat above 2000 feet is the lowest elevation at which a crust of perpetual ice can be formed in this country, and that this highland-ice no doubt may spread in ramifications through clefts and valleys to the lower country, and in some instances even down to the ocean, but that the ice formed at such an elevation, with the exception of very few cases, is only temporary. Neither do we find at the elevation of upwards of 2000 feet *perpetual* ice and snow in *every* place. On the contrary, below the 71st parallel of N. latitude, phanerogamous plants have been found at the elevation of 4500 feet. Further it has appeared, that the ramifications of the highland-ice or gletchers here, as in other climes, have a *progressive* movement. This movement is, however, extremely slow, and the increase of temperature in the lower regions often melts away their lower edges, so that only a few of the largest gletchers, which receive their tribute of ice from a great tract of highland, have been able to reach the coast; but the dropped fragments of ice (singularly called by the Danish colonists *calf-ice*) sent forth to the ocean by these glaciers, are so inconsiderable, that it may be safely asserted that the sum total of rain and snow, which in the course of the year falls on the *outskirts*, leaves them again in a *fluid* state. At the same time there is an observation, founded on experience, which may clear up these apparent contradictions, that the neighbouring *inland* continent is not only formed into a perfect level of ice, but also yields a large excess thereof to the ocean. It is of course manifest, that even in the low country there might be formed a crust of ice altogether indissoluble, if only the requisite quantum of water in due form was exposed to the action of the annual frost of eight months. This does not take place on the fresh-water lakes, where the ice rarely attains more than 6 feet thickness, owing to the protection afforded by the ice itself, as well as by the snowy carpet, against the frost. If, on the contrary, through the course of a whole winter, water were constantly poured over a surface perpetually exposed to the action of the atmosphere, there would no doubt be formed a crust of ice 20 to 40 feet thick, which the short summer would be incapable of melting. We see an approximation to this in several parts of the *outskirts*, where running water continues its play during the winter. When the snow in all other places is thawed away, we observe thick crusts of ice in the neighbourhood of certain water-springs, which continue running *throughout the year*. Nay, even near the sea-coast such a formation of ice is found, which has never been known for a certainty to have entirely melted. This,

moreover, is the case at the mouths of all the larger rivers, more particularly where they spread over a delta, the bed of which is formed of large stone blocks. Such rivers may, during winter, be fed with water, either from water-springs or from lakes, whether their outlet be direct or subterranean. The main point is, that the larger the territory the more difficult it will be for the water, which is received in the course of a summer, to gain sufficient time to reach the ocean *before the winter frost begins to stop it in its course*. But the *inland* region is particularly distinguished from the *outskirts* by the great extent of its water-courses, and by the distance over which the water must pass before it reaches the ocean. The old rivers may thus have been stopped in former times, and filled the valleys with ice, which again may have blended itself with that from the highlands, by which the icy covering of the whole was effected; but now this covering has extended to a height at which the above conditions for the formation of highland ice are rendered unnecessary.

The exclusive origin of the icebergs from the inland ice, through the icy friths, has been mentioned; but where these friths have a certain extent in an *easterly* direction, we find those valleys which ought to form their eastern continuation everywhere full of ice; and when, from a considerable elevation on the mountainous parts of the coast, they may be viewed or explored by vision, we observe that they rise, and at the same time *approach and unite*, in an icy level, occupying the whole of the eastern tract, or area of the continent. The elevation or height above the sea of this icy plain, at its junction with the *outskirts* of the country, and where it begins to lower itself through the valleys to the friths, is, in the ramifications of the Bay of Omenak, found to be 2000 feet, from which level it gradually rises towards the interior. The author has *in his journeys observed twenty-three such icy steps*, or platforms, to which must be added five or six delineated according to description. But although the icy level or plain, from which they appear to have their common origin, appears everywhere to have a uniform descent, there is still observable this remarkable difference, that certain of its ramifications are protruded with far greater force into the friths than others. This movement can be measured partly by the power with which the solid surface-ice in the bays, during winter, is broken through or disturbed in its usual structure and position, and partly and more particularly, by the quantity of ice which, in the form of *calf-ice*, and of icebergs, is annually produced, and carried through the icy friths to the ocean.

An estimate of the quantities of ice annually transported by the icy friths, which have partly been observed by myself, and partly derived from the information given by the inhabitants, has con-

vinced me of the existence of five principal ice-friths on the coast-line, from $67\frac{1}{2}^{\circ}$ to 73° N. lat. From these nearly all the large icebergs are produced, and every one of these inlets receives annually from the inland icy region many thousand cubic feet of ice. The principal ice-friths are as follows:—

1. That of Jacobs-haven, in $69^{\circ} 10'$ N. lat.
2. Of Tossukatek, behind the island of Arvemina, in $69^{\circ} 50'$ N. lat.
3. The large one of Kariak, in $70^{\circ} 25'$ N. lat.
4. The still larger one of Kanyeidbursoak, in $71^{\circ} 25'$ N. lat., both being ramifications of the Bay of Omenak.
5. And of Upernivik, in 73° N. lat., behind a large group of islands.

In considering the manner in which the ice moves from the interior down into the ice-friths, and its breaking up there; and how the *calving*, or liberation of the floating icebergs, is effected, the following special remarks may help to explain and illustrate the earlier views formed on the subject in different records of travels. Remembering that all icebergs are fragments let loose from the continental ice, it cannot be doubted that the parent mass must at least have been the thickness of the iceberg's smallest diameter. Accordingly the ice, which is pushed out from the interior through a valley into a great ice-frith, must be considered a plane body of at least a thousand feet in thickness; * on account of the brittleness of the material, this down-gliding motion cannot take place without violent disturbances, on which account its surface resembles a peaked, waved, and suddenly-congealed sea, which, besides, is cut through by numerous rents. In the meanwhile this weighty plane body preserves its continuity in progressive motion over the old beach on the bottom of the sea unchanged as when on shore, till the outer end has reached a depth in which the water begins to bear it up, where, still preserving its connection, it proceeds, thus borne up by the sea, till some exterior cause makes the connection cease, when the outer end breaks off and becomes a floating iceberg. This action is called *calving*, and such is the concussion, that it sometimes sets the sea in motion to a distance of 16 miles. From the above it is evident that icebergs cannot be considered as breaking off from the coast; it would be more proper to say, *that they rise* out of the sea; for in general the icebergs, advancing in front of the continental ice from whence they proceed, are higher at the inner end than at the outer end, which seems to be somewhat pressed down by the part behind, while it is gliding down the rocks at the bottom. Continental ice, or gletchers, which are exposed to much action of the sea,

* Most icebergs are upwards of 1600 feet thick, and draw more than 200 fathoms water.—F. B.

produce only *small ice-calves*, and *no icebergs*, or, at best, of small size. It is uncertain whether the continental ice advances gradually and regularly, or periodically. Its breaking or calving is altogether independent of this, as it seems to depend on outward causes, in such wise that the station or limit, to which the outer end may attain, is uncertain, and may sometimes proceed much further *without breaking* than at other times; so that even in the severest part of the winter it may send off large icebergs into the ocean. From November to June the water, in which the icebergs are to proceed to the ocean, is so covered by the ocean ice, that they are shut up in the inner ice-friths; but in July, and especially in August, they are carried in mass by the current to the open sea. This is called *the shooting out of the ice-friths*, which lasts till late in the autumn, when the continual easterly storms finally clear out the inner waters, unless the icebergs are intercepted by certain banks, on which they sometimes remain long aground.

It has been said above, that those parts of the *inland* ice, which are thus moved strongly down to certain friths, and which we have called *ice-currents*, may be assumed as pointing out the directions of the old rivers which flowed through the country before it was entirely covered with ice, and before the valleys through which they ran were level, as they now are, with the tops of the mountains. As in milder climes, the water is carried away from the land in a fluid state through rivers; here it is gathered and carried away detachedly in the frozen condition of *ice-currents*. We are especially led to this consideration by the quantity of the animal production in such places, where we could expect to see mouths of rivers forming outlets to a large continent. It is certain that, in the interior of the ice, reservoirs of water are preserved throughout the year; in some places mighty springs are seen to come forth under its outer edge, pouring out *clayey water* in continued quantity throughout the winter; but it is probable that such masses of water discharge themselves through fissures of the continental ice, in those places where it moves quickest down towards the great ice-friths. This flowing water, in the interior of, and *under the ice*, may perhaps contribute towards explaining its motion over large tracts of land in the direction of the ice-friths. Icebergs consist mostly of hard, brittle ice, of which the white colour originates from very fine lineal pores, uniformly divided through the whole mass, all being of the same size, equidistant, and parallel throughout the whole iceberg. This uniform structure may have arisen at the time it was formed in the interior of the country from corned snow—perhaps repeatedly thawed and frozen. The white iceberg is in many directions crossed by broad stripes of intense blue-coloured ice, which is

quite clear, and either contains no air-bladders, or, at all events, very irregular ones. These blue stripes are several feet in dimension, and in them are generally found "dirt bands" of foreign matters, such as stone, gravel, and clay, which the icebergs carry off embodied in them. The *blue* ice is, by thawing, dissolved into regular large grains, which is not the case with the *white* ice that forms the main mass of the icebergs. It seems probable that these blue stripes are formed by a filling up of the fissures in the *inland* ice with water—perhaps mixed with snow, gravel, and stones; and such a refrigeration of the water in the fissures may be supposed to be an important agency in setting in motion these great mountains of ice.*

XI.—On the Island of Ruad, North Syria. By Capt. WILLIAM ALLEN, R.N., F.R.S., F.R.G.S.

Read June 14, 1852.

THE power and prosperity of Tyre probably owed its rise to the simple advantage of an island, lying near a fertile coast, devoid of harbours. It is one among the numerous instances of what has been accomplished by the unfettered energies of a maritime people. Similar circumstances on the shores of northern Syria led to the same results. A colony of exiles from Sidon emulated the glories of Tyre in the little island of Aradus, the modern Ruad. Destruction here has not been so complete as at Tyre,—enough remains to testify to the boldness of the race, and to shadow forth the grandeur of its prototype in the South.

Although probably never so powerful as Sidon and Tyre, Aradus shared with them the honour of founding Tripolis, and its prosperity may be inferred from the description of Strabo, who says it was "habitationibus plenum; tanta hominum multitudine ad hoc usque tempus, ut domus inhabitent multis fastigiis aptas."

I made a little survey of this island in the spring of the year 1851. It is situated in lat. $34^{\circ} 49' 20''$ N., and long. $35^{\circ} 51'$ E.† There are two little ports, occupying the whole of the eastern side of the island, or that facing the continent, about 400 yards in length. This is the only shelter from the prevalent S.W. winds and heavy seas, that have the length of half the Mediterranean to rouse themselves in, before expending their fury on this open coast.

The ports are formed by three piers or moles, showing more or less their ancient construction, but especially that in the middle,

* See Dr. Rink's late work, 'De Danske Handelsdistricter i Nordgrönland,' with map. Copenhagen.—ED.

† According to Mr. Hooper, Master of H.M.B. "Frolic."